Defense Science Board

Open Systems Task Force

An

Open Systems Process

For DoD

Task Force Chairman - Dr. Wayne L. O'Hern, Jr.

FINAL REPORT

25 SEPTEMBER 1998

Table of Contents

Table of Contents (cont.)

Foreword

- Notes -

Executive Summary

- Notes (cont.) -

Executive Summary

- Notes (cont.) -

Executive Summary

- Notes (cont.) -

Executive Summary

- Notes (cont.) -

Executive Summary

- Notes (cont.) -

Tasking

- Formal Terms of Reference*
  - What are benefits and obstacles to an Open Systems Process?
  - What would we have to do to realize the benefits?
  - New and legacy systems; not just IT
- Initial discussions with USD(A&T), OS-JTF
  - "DoD has been working on Open Systems -- this is important, but we haven't gotten our arms around it"
  - "Need the Task Force to recommend a conceptual framework for proceeding"

This is not an esoteric report about formal "Open Systems" --
It is about exploiting Lessons Learned from the Open Systems experience to achieve a major advance in DoD combat and acquisition effectiveness

** See Appendix A*

Members*

Dr. Wayne L. O'Hern, Jr., Chairman	**Technology Strategies & Alliances**
Mr. Jack E. Bloodworth	Boeing Company
Lt Gen Bruce K. Brown, USAF (Ret)	consultant
Ms. Shawn A. Butler	Carnegie Mellon University
Dr. Larry E. Druffel	SCRA
Dr. Vitalij Garber	Garber International
Mr. Jeff Harris	Space Imaging EOSAT
Lt Gen Carl O'Berry, USAF (Ret)	Motorola
Mr. Tofie M. Owen, Jr.	SAIC
Professor Dee Ritchie	Georgia Tech
Mr. James M. Sinnett	Boeing Company/St. Louis
Dr. David E. Sundstrom	Lockheed Martin
Mr. Chris Waln	TASC
Mr. John Wehmeyer	SRI International
Professor Patrick Winston	MIT

** See Appendix B*

Conclusions

- Open Systems Process is fundamental to many DoD priorities that are dependent upon a process-based approach
  - JV 2010 and Service equivalents
  - Force modernization
  - Reduced cycle time and ownership costs
  - Favorable industrial base realignment

Open Systems Process is a Warfighting and Title 10 *essential core value*

- Forces, systems, and processes need to leverage change:
  - Configure Forces, systems and processes for continuous viability
  - Achieve architecture-driven modularity
  - Manage to the natural cycle rates of underlying components
- Open Systems Process is based upon a hierarchy of architectures and standards developed with a performance-based collaborative approach
- Unlikely that DoD can implement Open Systems Process by usual bureaucratic means
  - *Open Systems Process is a cultural and budget challenge*-- process is within our grasp
  - Requires support from DoD, Administration, Hill, and Industry
  - Need to reconfigure Forces, systems, and management processes
  - Removing impediments is most important

Requires aggressive leadership, SecDef and Service Secretary championing

Conclusions

- Notes (cont.) -

Some Terms

- A remarkably small vocabulary is used with little differentiation to describe a broad range of concepts, hindering critical thinking and effective communication
- For this report we use the following terms to differentiate key concepts:
  - ***Plug & Fight* (Force Level)** or ***Plug & Play* (Component Level):** The ability to readily incorporate functionally compatible parts on short notice
  - ***Open Systems Process (OS Process):*** The process of achieving Plug & Fight/Play
  - ***Architecture:*** The overall structure of a solution
  - ***Open*:** Modular architectures with completely defined and publicly available interfaces, supported by consensus-based standards
  - ***Openness*:** The degree to which an architecture or standard is open
  - ***COTS:*** A commercial catalog item -- ***COTS is not necessarily Open***
  - ***Practical Open:*** Most practical [vs. most pure] Openness
  - ***F^3I:*** *Specifying* Form, Fit, Function, and Interface (F^3I) to permit Plug & Fight/Play

Why We Care

Why Do We Care?

- Here is what the leadership has said:
  - **JV 2010**: "Applications of new technology will transform the traditional functions of maneuver, strike, protection, and logistics. *These transformations will be so powerful that they become, in effect, new operational concepts* …. These operational concepts will provide our forces with a new conceptual framework."
  - **Concept for Future Joint Operations: "**The key characteristic we seek for our Armed Forces is the ability to conduct dominant operations across the full range of possible missions."
  - **Secretary Cohen**: "In March, I went out to see the U.S. Army's Force XXI experiments …. It was an awe-inspiring demonstration …. Force XXI is the much-vaunted Revolution in Military Affairs made real …. I knew that the technology I was seeing was key to U.S. military superiority in the future."

But DoD is already on a downward spiral, even with today's missions …
It is unlikely that either JV2010 or the Revolution in Military Affairs can occur without a major change in how we configure our Forces, Systems, and Processes

Why We Care
- Warfighting -

- Emerging CONOPS will be pick-up actions: collaborative, quick responses to uncertain enemies in remote, poorly understood locations with little infrastructure
  - Ability to quickly integrate and execute will be a core warfighting competency
  - Quick response requires ability to constitute, configure, and execute Forces on the run
  - Highly integrated, mutually dependent, joint operations with coalition Forces
- CONOPS massively dependent upon ready constitution, dynamic collaborative planning and execution, and JV2010-style sustainment
- Can't get there from here without a quantum increase in Plug & Fight capabilities across the force: training, planning, deployment, ops, sustainment, support
- Analogous to Reliability for the Air Force in early '80s

"The high availability of our front line aircraft was a major factor in the outstanding Air Force performance in Desert Storm! Plug & Fight has a similar potential for quantum improvement and could be our next great leap forward"

General (Ret) Larry Welch, former Chief of Staff, U.S. Air Force

Why We Care
- Title 10, Training and Equipping the Force -

- Acquisition and Support
  - Current processes are based on a world which no longer exists
    - Requirements and technology evolved slowly in most areas
    - Parts presumed to be available at reasonable costs over long periods
    - Could repair, rebuild, or replace from detailed drawings, part lists
  - Although these conditions no longer exist, our processes haven't changed accordingly
  - Our acquisition and support centers are *in extremis*
- Train-As-You-Fight
  - If training with component, joint, and coalition Forces is to be effective, Forces must be much more Plug & Fight-capable than they are today

Why We Care
- Conclusions -

- The world has changed ....
  - Operational demands are up, not down
  - Investment and O&S accounts likely to remain at reduced levels
  - Changes in industrial base are leaving DoD behind
- DoD can neither *Equip, Train, Support, nor Fight* in this new world without major advances in Plug & Fight capabilities
- OS Process is no panacea, but enduring solutions are unlikely without it
- We find no viable or practical alternative

OS Process is critical to
future warfighting and Title 10 responsibilities

Pilot Open Systems Efforts Have Produced Impressive Results

- Army Intelligence and Electronic Warfare Common Sensor (IEWCS)
  - Interchangeable and interoperable common modules; VME interface standards
  - Replaced six legacy systems; increased interoperability; reduced development & production costs by 40%, R&D time by 64%, EMD time by 29%
  - Navy's New Attack Submarine (NSSN)
  - OS Architecture implemented through an OS IPT & Modular Design
  - 2:1 reduction in development time
  - Greater than 5:1 reduction in development costs
  - 4:1 reduction in procurement cost
- F-15, F/A-18, AV-8B common processor pilot programs
  - Cross-program modular HW & SW interfacing with legacy platform and subsystems
  - Expecting about 50% improvement in development and O&M costs
- Seventh Fleet Command Ship (USS Blue Ridge)
  - Converted Mission and Housekeeping functions using OS Process and COTS
  - Modified ship structure to enable open, rapid reconfiguration

Pilot Open Systems Efforts Have Produced Impressive Results

- Notes (cont.) -

An Open Systems Process Tailored for DoD

The Vision

Enabling DoD to affordably configure and integrate Forces, systems, and processes for high combat effectiveness and life-long viability

A Tailored Open Systems Process for DoD

Topics

- Critical OS Lessons Learned
- Maintaining System Viability Throughout Desired Lifetime
- Architecture-Driven Modularity
- Administering an Open Architecture
- Standards and Openness
- Risk of Adopting an OS Process
- Managing to Enable Natural Cycle Rates
- Configuring Systems for High Cycle Rates

OS Process is the principal foundation for achieving Plug & Fight/Play and COTS economies

Critical Open Systems Lessons Learned for DoD

The Nuggets

(1) Configure Forces, systems and processes for *continuous viability*

(2) Achieve architecture-driven modularity

(3) Manage to the natural cycle rates of underlying components

- U.S. Forces, systems, and processes severely threatened by their lack of agility in dynamic world
- For systems, today's threat domains include not only combat capability but also inadequate affordability, response time, sustainment, eroding supplier base

Must configure for constant evolution in a dynamic world

- Our Forces and systems must be rich in "smart" modularity, driven by architecture, and configured as a hierarchy of modular "sockets" enabling adaptation in a dynamic world
- Must revamp our management processes to encourage and leverage the natural cycle rates of the underlying components

The primary benefit of the OS experience for DoD is not so much about mandating pure "Open" solutions as it is about extensive, wise modularity and a significantly enlightened management approach

Analyzing and Addressing Viability Risk
- A Strawman Approach -

The fact of program-threatening evolution is *absolutely certain* --
Need to develop explicit risk mitigation strategies

Step 1: Risk Analysis: Characterize expected evolution and cycle-rate of the key factors affecting viability *throughout the life* of the product

- Likely topics include: affordability, technology, subsystem characteristics, external interfaces, requirements, supplier base
- (Attributes for life-long viability probably needed just to get through EMD -- witness F-22)

Step 2: Apply Plug & Fight/Plug & Play/Openness as critical attributes

- Example program tasks: concept development, analysis of alternative, acquisition strategy, tailored program management scheme
- Example OS topics: continuing affordability, evolving connectivity, tech refresh, suppliers

Step 3: Demonstrate that *architecture* gets best life-long viability within available resources

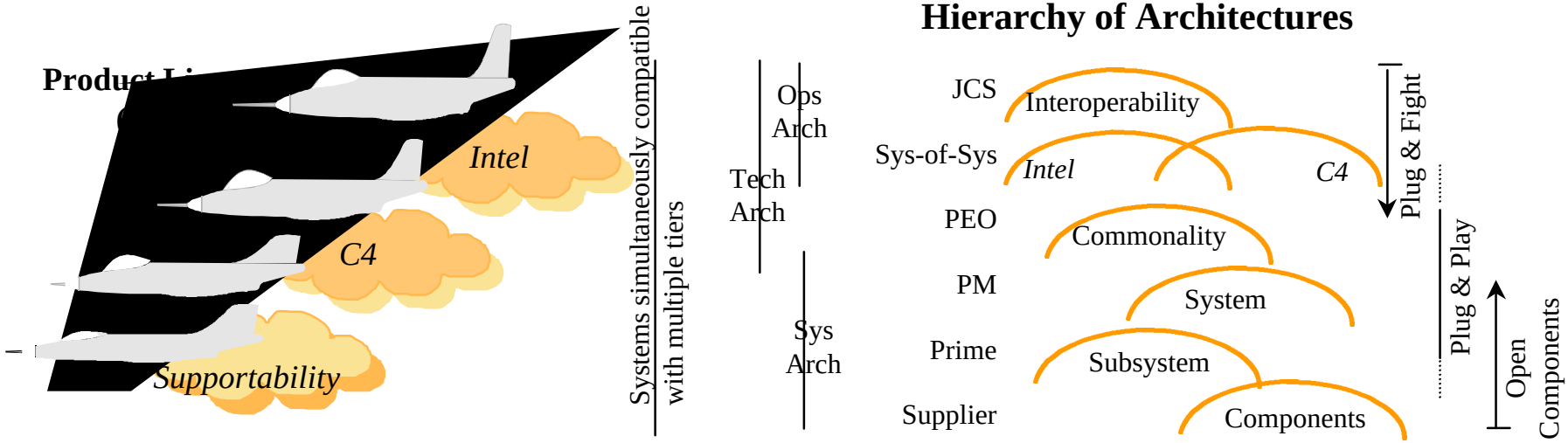
Step 4: Include OS Process in all relevant procurement matters

- e.g., Requirements, specifications, ***Source Selection Criteria***, etc.

Make sound life-long viability a mandatory milestone review item

Architecture Driven Modularity

Capturing the benefits of *Plug & Fight, Plug & Play,* and *Commercial OS* requires a hierarchy of architectures



Axioms

- Plug & Fight, Plug & Play, and Open components are related but different
- Each must be individually nurtured, but in a coordinated, mutually supportive approach
- Each must impose only the minimum essential requirements, or they will stifle the others
- Ops, Tech, and Sys Architectures each have different sponsors, as does each tier of the hierarchy
- Forces and systems must be simultaneously compatible with all relevant architectures in the hierarchy

Hierarchy of Modular Architectures

- Notes (cont.) -

Partitioning for Modularity

Good modularity demands robust isolation of constituent elements, connected only through interoperable interface specifications

- Design attributes:
  - Modularity - Element substitution and renewal
  - Portability - Reuse and resource sharing
  - Scalability - Ready modernization and growth
- How much?
  - System-of-systems needs
  - Operability and interoperability
  - Commonality (horizontal, vertical, across functions)

Attributes often compete -- for example:

- MS Windows gives broad commonality but poor interoperability and reliability
- Apple gives interoperability and reliability but limited commonality

- Decomposing the system
  - Emphasize open partitioning, leverage standards, get expert advice
  - Need hard isolation of modules, interact *only* through interface specs
- Implementation
  - Designated system-of-systems and system architects
  - Mechanisms to assure local decisions don't compromise system design
  - Test attributes sought
  - Tight discipline throughout life cycle; don't let attributes dissipate

DoD Already Understands the Basics

- Similar to Architecting for Software Development -

- OS Process in DoD today is analogous to software development 20 years ago
  - Was art, now art + discipline with axioms, institutions (e.g. SEI), and milestone exit criteria

Very good architecting is as essential for good modularity as for SW development -- A flawed architecture compromises all that follows

- Key outputs are overall structure, partitioning, and interface standards
- The basics are at hand and already understood -- ***it's mostly a matter of doing it***
- Systems architecting is a discipline of balancing dissimilar requirements such as CONOPS, schedule, performance, risk, supportability, reliability, and cost, according to the customer's relative priorities
- Only one or two attributes usually can be constrained, but good architecture optimizes the mix
- The architecture needs to follow Open principles, even if the parts are less than Open
- But even if parts not Open, must follow the OS Process tenants, or product will almost certainly be monstrous to employ and sustain

<u>Axiom</u>

Architecture-driven modularity is requisite to achieving OS attributes -- therefore, OS Process should be a *mandatory* and *non-negotiable* discipline for *all activities* configuring Forces, systems, and processes

Developing and Sustaining a Hierarchy of Architectures
- Some Institutional Imperatives -

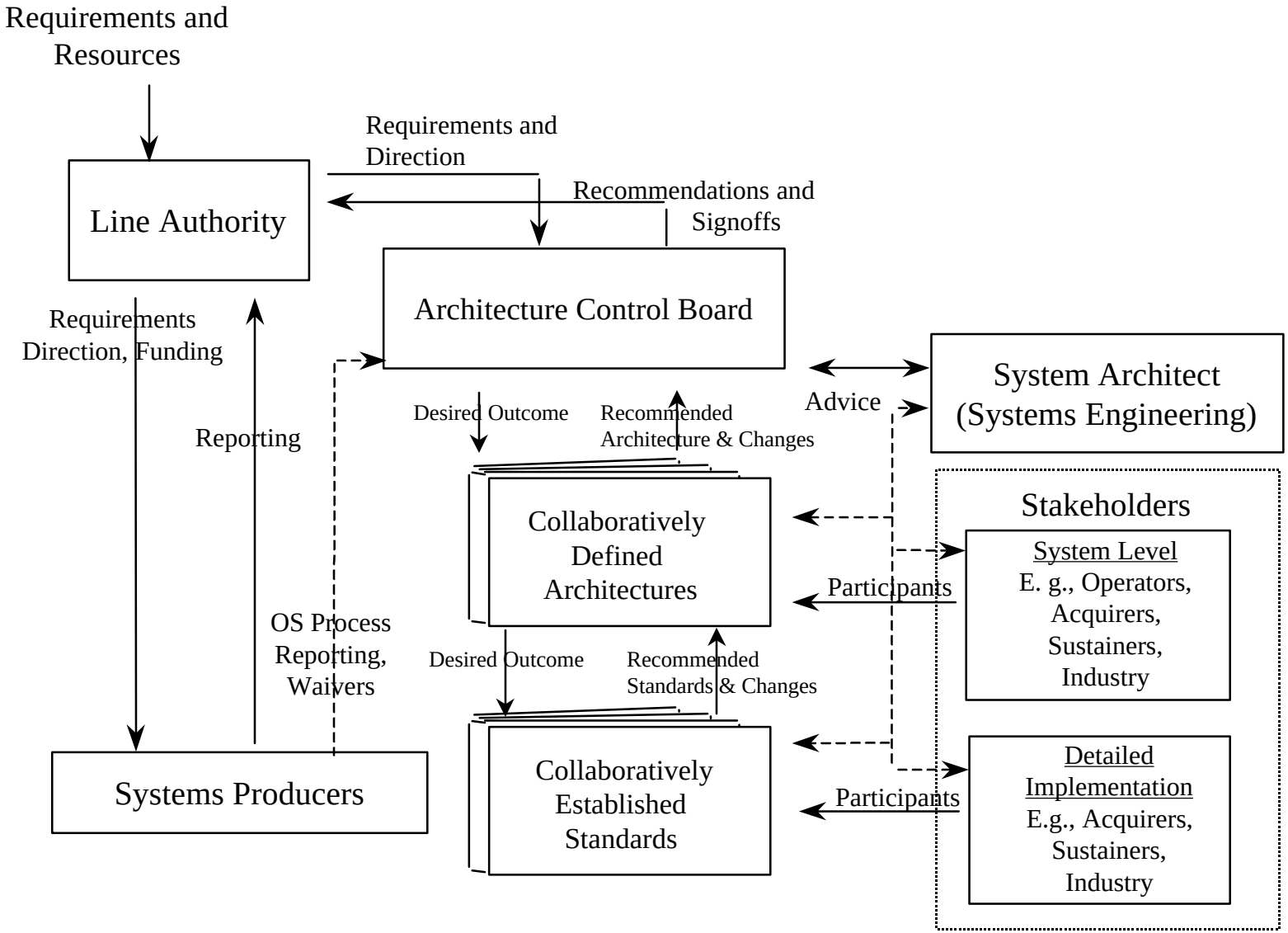
- We have all been scared by blanket imposition of well-intended *causes de jour*
- While desired outcomes and constraints can be mandated, detailed solutions should be collaborative amongst the stakeholders (and be prepared to motivate intransigent stakeholder.)
- Achieving a widespread DoD OS Process will require aggressive championing, but anointed "do it my way" czars will be successfully resisted at all levels
- Through Acquisition Reform, DoD digging out from under the regulatory heap that was burying it
- ***Need for OS Process become a mindset and core value, not another massive bureaucracy***

Axioms

- **Only the vital, bare minimum constraints needed to do the job should be imposed, and at the highest functional and organizational tiers practical**
- **Our performance-based acquisition should also be our OS Process:**
  - **Higher tiers identify needed *outcomes* and assure high integrity processes**
  - **Stakeholders in the solution devise the *how***

Administering an OS Architecture

- Generic OS Process Model -

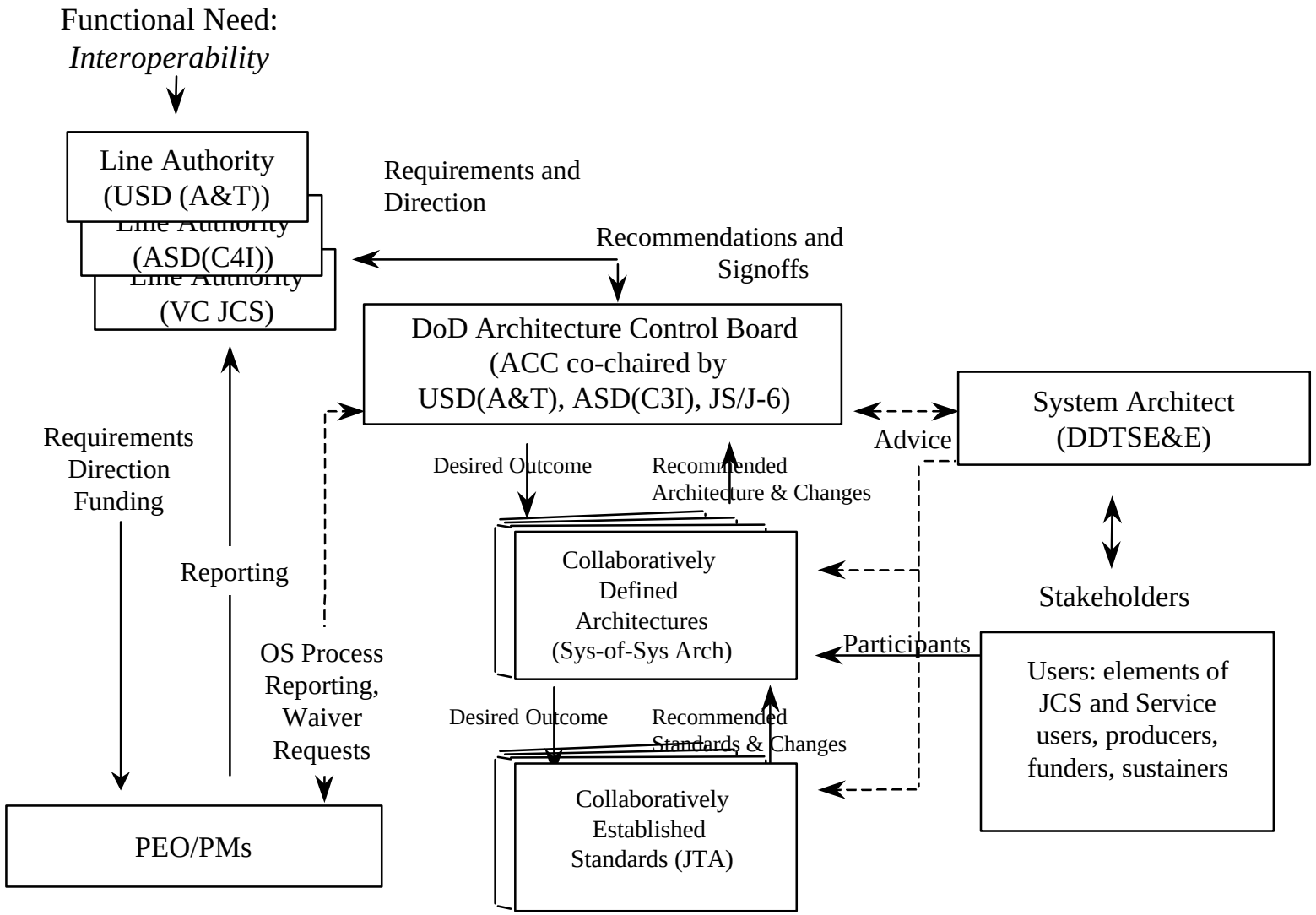


Administering an OS Architecture: Generic OS Process Model

- Notes (cont.) -

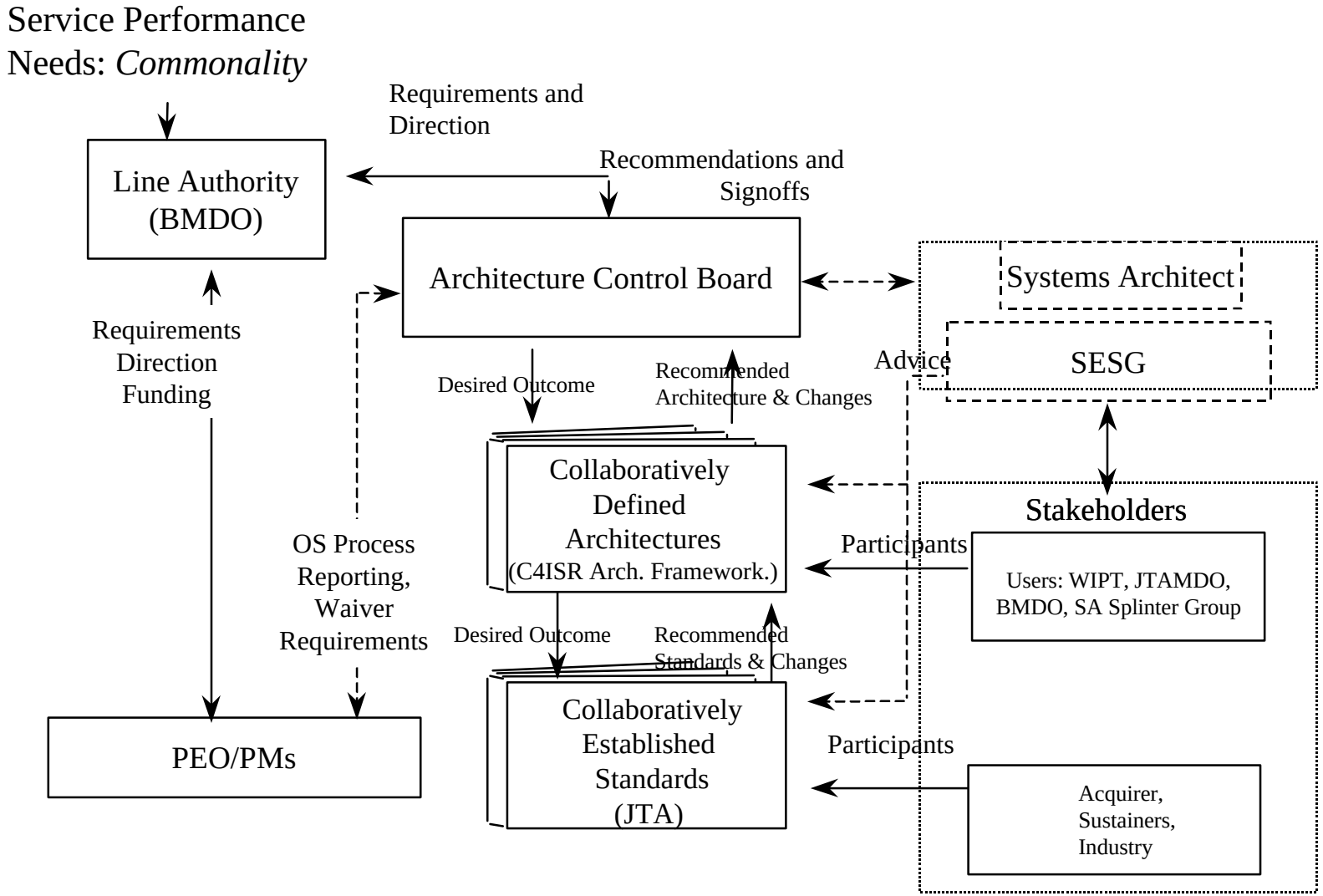
Force Level Interoperability

- An OSD/JCS System-of-Systems Application -

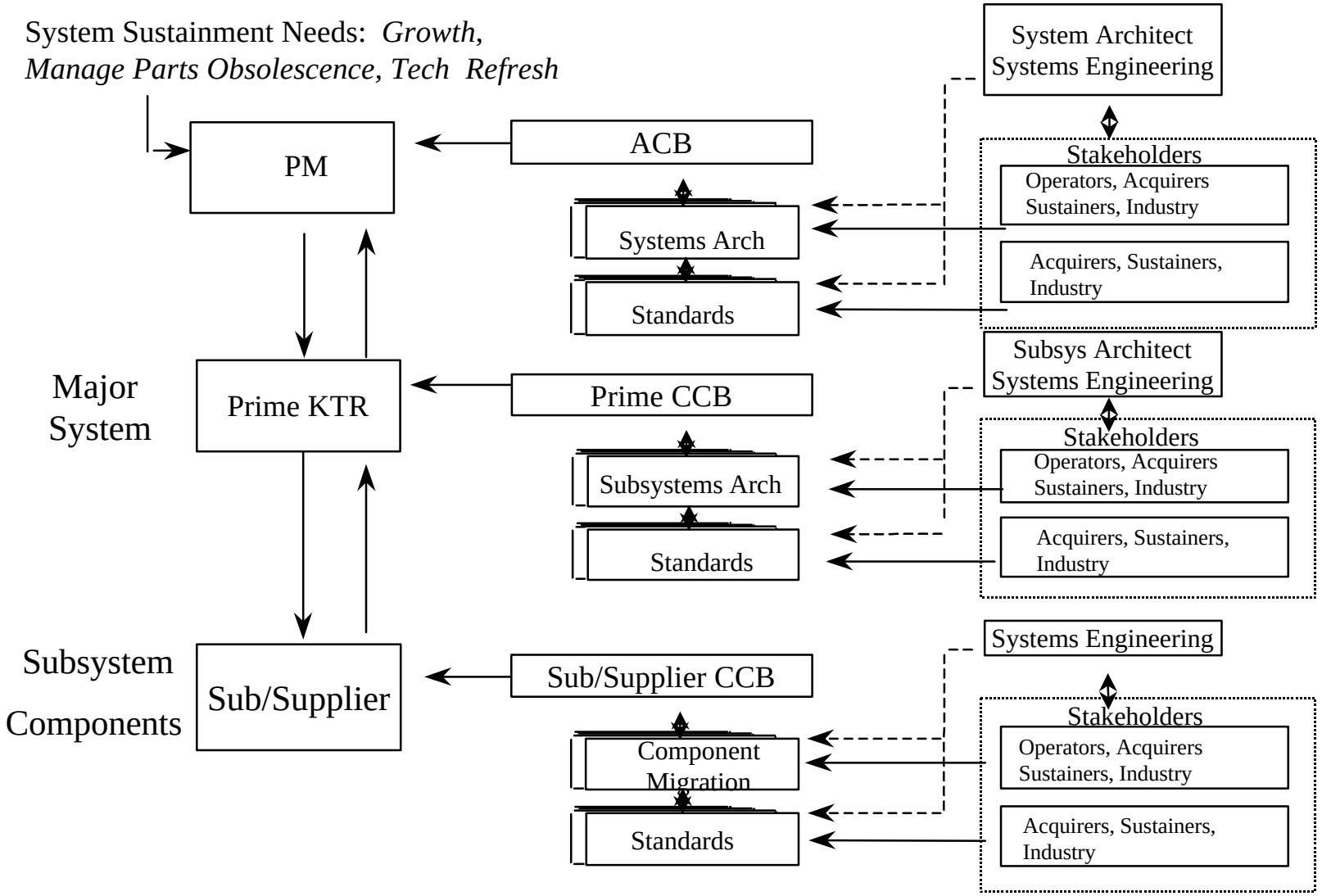


Single Integrated Air Picture

- An Emerging Joint System-of-Systems Application -



Weapons System Level Application



Standards and "Openness"

- Standards define the inter-module connections ("sockets") which enable modularity
- "Open" refers to use of interfaces and protocols that conform to well defined, widely used, preferably non-proprietary standards. Open standards are those developed by recognized standards bodies or the commercial marketplace. Standards may be:
- open (or public): e.g. tires, electric outlets, some GPS data formats
  - owned: e.g. most car parts, MS Windows 95
  - de facto: e.g. 8.5" x 11" paper, typewriter keyboard
  - proprietary: e.g. most weapons systems key components
- The level of Openness refers to the system design level at or above which interfaces conform to Open standards
- The level of Openness determines the extent to which a weapon system can:
  - Use multiple suppliers for competitive procurements through its total life cycle
  - Insert new hardware and software technology whenever available
  - Assign the control of design, repair, and replacement to the supplier
- An "80%" quick, Open solution which is affordable and sustainable is usually better than a functionally ideal solution which we probably can neither afford nor sustain

Axiom

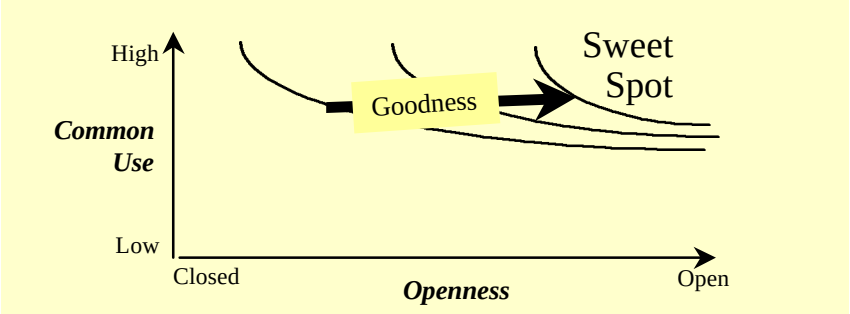
Strong presumption for the "most Open" solution

Sometimes "Less Open" is the Best Answer

- But the Burden of Proof Should be Rigorous -

- OS Process presumes "most Open," but that is not always feasible; less Open is sometimes desirable in upgrades of legacy systems with limited remaining lifetimes where adoption of Open standards is not economically feasible
- Less Open often applies when:
  - Easiest subsystem or component changes, upgrades, or replacement are not needed
  - Cost effective insertion of rapidly advancing technology is not required during remaining life cycle
  - Cost reduction through competition is neither viable nor economically desirable
- Sometimes less Open solutions really do enable better CONOPS, supportability, functionality, and even total life cycle costs

Choosing Standards



- **Criteria** (some may be in conflict -- requires engineering and business judgment):
  - Consistency with the architecture
  - Does it work well in this application?
  - Degree of Openness, breadth of use, and continued support
  - Robust capability for future evolution of system throughout life cycle
  - Extent of Plug & Fight (ex: coalition warfare ⟶ commercial standards)
- **Increased care must be used when:**
  - A standard has not matured (e.g., CORBA)
  - Proprietary extensions necessary for performance requirements
  - Multiple standards exist for the same function
  - A standard does not exist and new work needs to be reusable
  - ***Avoid hollow standards!***

> ***"Practical Open"*** **= Widely used and supported, as Open as practical (wide use outweighs Openness)**

Choosing Standards

- Notes (cont.) -

Risks

- Risks associated with “more Open” options include:
  - Budget and Service investment philosophy:
    - Upfront $$ required for OS Process systems engineering
  - Backward compatibility within legacy systems can be expensive
  - Need to sway industry standards bodies; requires early proactive involvement
  - Industry concerns over proprietary data and investment for competitiveness
  - Availability of standards, their evolution & obsolescence
  - Market acceptance of emerging standards not assured; need backup plans
    - ***But, taking a chance and guessing wrong is still “cheaper, faster, better” than developing a DoD-unique solution***
- Enabling future reuse requires additional $$, offset by reducing recurring test $$ -- ex: recurring SW regression testing costs DoD **$**B/year
  - Numerous methodologies and technical challenges, but within our grasp
- Even with all this, ***U.S. government process impediments are the single greatest risk***

Risks are real, but are dwarfed by the benefits;
Up-front funding a major problem

Risks

- Notes (cont.) -

Managing to Natural Cycle Rates
- Parsing Systems by Natural Cycle Rates -

- **Mildly constrained**

  ex. Command Post, including airborne & mobile; shipboard and sub electronics

  – Rack typically isolates boards from platform environment
  – Adequate weight, space, power, cooling; rack interconnects flexible
  – High leverage of commercial technical and business practice
- **Severely constrained**

  ex. tactical missiles

  – Some commercial components but not boards
- **Tightly constrained**

  ex. Tactical aircraft avionics

  – Enclosure can isolate boards from platform environment
  – Tightly constrained weight, space, power, cooling
  – Enclosure interconnects inflexible
  – Can achieve many commercial advantages, but need new approaches

The March of Technology Ought to be Saving Programs

- Managing to Let It Happen -

March of Technology-- Radar Processor example

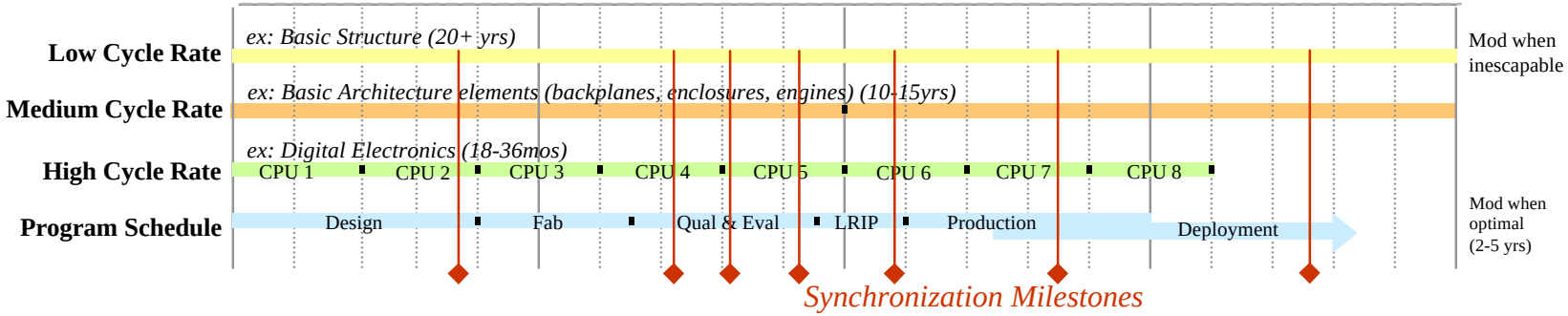
ex: Industry Radar Signal Processing Projections

Late '80s	Early '90s	Today	~2000	~2005
8 boxes	2 boxes	2 boxes	1 box	0.5 box
9ft3	3ft3	2ft3	1ft3	.5ft3
capability x1	capability x2	capability x4	capability x6	capability x10
$2M	$1M	$0.5M	$0.3M	$0.1M

Typical System Acquisition Timeline

Concept Def — Development — Test — LRIP — Production →

Think of systems and processes as the means to harness change: Encourage natural cycle rates, synchronizing at key milestones



- Cycling continues throughout the entire life of the program; PM responsible for full life
- Measures needed for sustainment also needed for EMD
- Controls configuration with architecture and F^3I "sockets", not at piece/part level
- OS architecture enables concepts such as Spiral Development and Evolutionary Acquisition

The March of Technology Ought to be Saving Programs

- Managing to Let It Happen/Notes (cont.) -

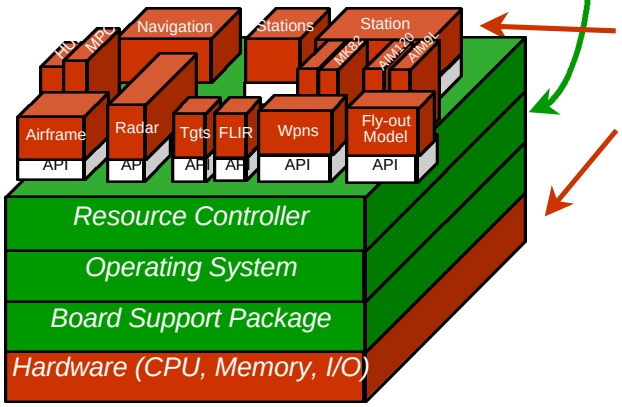
Product Configurations to Enable High Cycle Rates

- Decoupling System Elements -

TACAIR avionics -- a stress case and major investment cost

SOFTWARE

Common Software Architecture



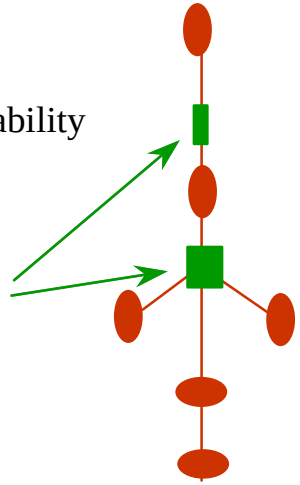
Architecture, language, and operating system provide medium cycle-rate stability

Application and HW host cycle at natural rates

HARDWARE

AIRCRAFT PORTION
(racks, cables, connectors)

- Inflexibility, poor reliability
- ***Massive upgrade cost***
- Stifles currency



PLUG & PLAY AVIONICS ENCLOSURES

- High-performance board F^3I, backplane
- Robust connections to cockpit and outboard equipment bays
- Avoids many aircraft-side failures and upgrade $$$
- Subsystem evolution addressed at board level

System Elements Decoupled:

Software	**Cycle Rate**	**Hardware**
------	Low (20-30 yrs)	Air Frame
Arch, language, op sys,	Medium (10-15 yrs)	Enclosures, cabling
Applications, (processor)	High (3-5 yrs)	Board components

Product domains can be decoupled; natural cycle rates can be enabled

Configuring Systems for High-Cycle-Rates Components

- High cycle-rate items are mostly electronics
- Most DoD electronics can be readily configured for good commercial OS Processes
  - Isolating commercial elements from platform environment preferable to MILSPEC hardening *(ex: already have commercial boards on tactical vehicles, surveillance aircraft, subs)*
  - Permits frequent technology refresh to preserve suppliers, relieve problems, reduce costs
  - Need good F^3I at enclosure and board level
  - Well partitioned functions enable asynchronous evolution, modernization through spares
  - Subsystems can even be rearchitected *(ex. repartitioning signal and data processing)*
  - Suppliers can refresh boards as needed; minimum platform and subsystem impact
  - Commercial standards -- offer most benefits, but works even when unique *(ex. tac missiles)*
- Apply philosophy on a broad scale in other domains *(ex. electro-mechanical, power supplies)*

Axiom

Manage enclosures as F^3I sockets, not as frozen configuration items; Let board configurations cycle as needed within the F^3I standard to accommodate rearchitecting and high cycle-rate components

Status

The OS Process Concept is New --
How Close is DoD?

Open Systems Process Status

- Force Level -

Forces have embraced OS attributes only in *very narrow areas*
(ex: some C4ISR interoperability)
Not embraced as a broad ***enabler***, even in areas of seemingly equal importance**
(*ex: interoperability of logistics management processes*)

- OS Process for JV2010
  - Impelling grass root initiatives *(ex. Pacific Fleet Command ships)*
  - Do not see substantive funding of real projects within U.S., nor within allies and coalition partners
    - Joint planning, deployment, battle management, engagement, sustainment
    - Time to first significant FTX longer than WW II
  - Joint capabilities accepted at personal level, but don't compete in Service budgets
- OS Process in general
  - Not cornerstone of vision for long-range viability and effectiveness
    - Minimal requirements, plans, investment, metrics, training, etc.
  - Minimal Service commitment; not seen as high-leverage solution
    - Perceived very narrowly -- fix specific problems; minimum initial cost, performance
- Weak follow-through on current policies and directives; few penalties for non-compliance
- Services activities are generally unique (Title 10 prerogatives)

Open Systems Process Status

- Force Level (cont.) -

- Little management attention to exploiting OS to meet challenges
  - Few plans (OS Process not internalized or incorporated into daily processes)
  - Few metrics (no means to evaluate cost savings)
  - Little training
  - Little investment
  - Inadequate follow through on current policies and directives
  - Few penalties for non-compliance
- The Services are not currently committed to OS

•Acceptance of OS is through Commitment

- **Active leadership**
- **Emphasis on people and training**
- **Participation in standards organizations**

Open Systems Process *Status*
- Acquisition and Support -

- **Potential is staggering; exciting initiatives underway**
  - OS-JTF & DARPA pilot programs, Joint Aero Commanders' Group F^3I
  - Cross-system work (F-15//F/A-18//AV-8B; Sub Combat System)
- **But generally, DoD doing poorly**
  - Not yet truly embraced by Services or most Program Offices
  - Don't yet have a unifying concept; hampers institutionalizing process
  - Hobbled by
    - Inadequate appreciation of the benefits of an OS Process
    - Poor plans, processes, training, funding flexibility, metrics, compliance with policies & directives
    - Rigid statutes, policies, bureaucracy
    - Inadequate top-down emphasis and structured incentives
  - The fundamental problems are common across new and legacy systems alike
  - Legacy systems and sustainment are particularly disadvantaged
    - Crippled by old architectures
    - Legacy upgrades compete poorly in current budget crunch
    - Absence $$$, little progress likely

OS could have massive benefits, but OS Process has not really arrived;
Our management processes are crippling, self-inflicted barriers

Open Systems Process *Status*

- Acquisition and Support (cont.) -

Revamping Program Management and Oversight Processes

Revamping Processes and Tools

The reengineering of DoD processes and tools is itself a systems engineering task -- Need an integrated approach to the whole program management and oversight process

- Mindset and Core Values, Behavior
- Requirements
- Program Management
- Specifications and Contracting
- Test and Evaluation
- Funding

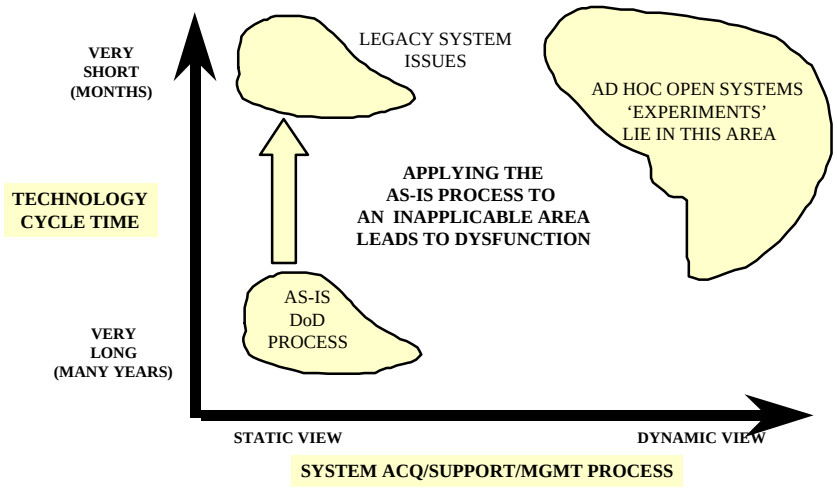
Need to cover all elements of the system life cycle

Revamping the Management and Oversight Process

- Changing the Way We Think and Do Business -

- Traditional Program Manager's mantra: Change is an enemy
  "Baseline to point solutions; shoot anyone who wants to change anything"

- Static solutions to dynamic world
  - Freeze and develop,
  - Freeze and test,
  - Freeze and produce



- **Traditional way doesn't work any more ... the world *<u>is</u>* change**

The process conflict arises from greatly shortened technology cycle times

Requirements
- Demanding OS Attributes as Mission Critical -

- When challenging dead end architectures and technologies, a frequent reply is: "…under intense scrutiny, absolute requirement to minimize cost and risk"
- Severely disincentivizes investment beyond the minimum immediate need -- all potential outcomes for Program Manager are downside, little upside reward:
  - "We have dead-end, stovepipe systems because we disincent anything more"
  - The most powerful incentive for the OS Process is to correct the disincentives
- Requirements need to demand:
  - Plug & Fight/Play in favor of the last increment of individual performance
  - Configurations which will be viable in the long run, staying abreast of:
    - Evolving force and operational needs
    - Realities of budget, technology, and supplier availability
  - Robust migration path
- Facilitate reuse of new work by others (documentation, transfer assistance, etc.)

Requirements need to demand:

- OS Process attributes of Plug & Fight/Play and COTS affordability
- System configurations and robust migration plans for life long viability

Core Mindset for Program Management
- OS Process Must Permeate Whole Structure -

- At the Program level, OS Process will become a survival core value
- System solutions start with understanding the problem to be solved
  - System definition phase must include a Viability Risk Analysis and required interfaces with related architectures
  - OS-compatible analysis tools should be accessed -- partitioning, cost, technology and obsolescence projection, etc.
- Architecture-driven modularity developed in system engineering process enables Plug & Play HW and SW, and reuse -- *minimizes constant regression testing*
- OS Process attributes and robust migration plans demonstrated in System Concept Definition and intergrated into Performance Specifications
- Management processes nurture natural cycle rates of components and interfaces
- Enabling Program Management infrastructure also demonstrated; for example:
  - Acquisition plan, review processes, and criteria
  - Architectural Control Board (ACB) and compliant architecture hierarchy
  - Contracting and Source Selection criteria
  - Test, product support, training
  - Diminishing supplier program

Must permeate <u>entire</u> acquisition management processes, Source Selection criteria, and milestone and upgrade reviews

Core Mindset for Program Management

- OS Process Must Permeate Whole Structure/Notes (cont.) -

Contracting and Source Selection
- Encourage OS Processes -

- Revamp the FAR
  - Natural extension of Performance Based Business Environment (PBBE) already started
  - Eliminate regulated obstacles to OS Process
  - Impose architectural hierarchy and ACBs
  - Align contract structure with system architecture (development through support)
  - Make OS Process a required Source Selection Criteria
- Reorient Specifications and Interface Control Documents
  - Specify and baseline system-level functionality (PBBE) and F^3I (OS) interface control
  - Manage high cycle-rate functions to F^3I and mitigation plans
    - Contractors and suppliers have lower tier configuration control within F^3I discipline
    - Abandon build-to-print process in favor of interface specifications
    - Contractors analyze best use of resources across all criteria
      - Implement program and migration plans by most economical process
      - Focus on best system/component/part value
      - Freedom to innovate using competitive pricing
    - Minimizes Class I changes
- Strong OS Process treatment in Source Selection

Force OS Process to become an industrial base core competency

Test and Evaluation

- New Philosophy: Validate Functional Performance and F^{3}I Provisions -

Many interviewees consider current test practice a crippling OS Process impediment

- Test philosophy must acknowledge that configurations are temporal -- they *cannot* pre-exist or endure
  - IOC configuration cannot pre-exist at OPEVAL
  - OPEVAL configuration cannot pre-exist at qual test
  - Configurations probably not even constant across test units
  - Product support must deal with continually evolving configurations
- Early functional testing may have to use surrogate hosts
- Must reengineer test flow to test functionality, F^{3}I, and migration path early, then balance other test needs with reality of evolving product configurations
- Avoid full duplication of tests between configurations, contractor, government
  (ex. Software regression testing is usually very expensive and often unnecessarily duplicative)
- Testing must be tailored to the phase of evolution of the product requirements

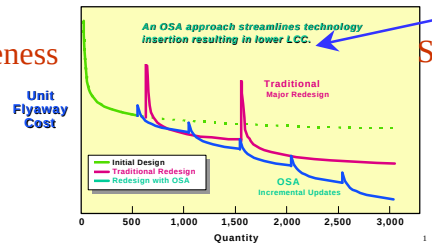
Must revamp test objectives, philosophy, criteria;
Need demonstration programs

Funding
- Current Practice Causing Serious Difficulties -

- Maintaining system viability requires overall life cycle Responsibility, Authorities, and Accountabilities (RAA)
  - PMs generally have life cycle responsibilities, but neither authorities nor resources
  - Let PMs balance the pain between NRE and recurring O&M
  - Assign PM's total life cycle RAA
- Colors-of-Money (RDT&E vs. Production vs. O&S) inhibit effective technology renewal
  - For high-cycle-rate elements, problems and their solutions extend across color boundaries
  - Support problems just as bad in R&D and Production phases
  - Need relief to allow technology renewal with any color-of-$$ available

Current Practice
Major drop in capability
Large mods hard to fund

Sys Effectiveness



Sys Effectiveness

Open Systems Process
Retain capability
Changes easier to fund
Some don't require govt $$

- Funding need changes are very difficult for most programs
  - Changes mostly accumulate until major system upgrades; often involve expensive platform mod
  - Changes plus mod cost difficult to fund; jeopardizes program
  - OS Process could spread changes, avoid many mods; funding more likely

Funding

- OS Process Can Improve the Situation/Notes (cont.) -

Infrastructure Needs

- Tools for program planning, cost modeling, budgeting, sustainment
  - Planning tools incorporating high cycle effects and OS effects are immature
  - Couldn’t find cost estimating tools -- some being started
- Acquisition processes need to be reengineered from PDRR through Support
  - Strong disciplined systems engineering essential; grow competency by multiples
  - Decrease component design and test engineering
  - Develop management and integration techniques to marry low cycle change elements with high cycle change elements later in process
  - Confirm HW & SW structure very early -- before application development
  - New functional validation and design review exit criteria
  - Test philosophy: Minimize duplication, qualify SW early, qualify HW late, update SW always
- Currently training is very limited
  - Not a curriculum topic in DoD professional schools
  - Acquisition and logistics workforce not trained to PBBE and OS Process
  - Functional and interface discipline vs. “how-to” and “build-to-print” specs

Industrial Base

DoD-centric analysis argues strongly for imposing extensive OS requirements -- need to consider impact on industrial base

- Business basics require that investment be recovered and profit made
- Impact of imposing OS requirements on industry
  - OS greatly reduces non-recurring and recurring cost, which equals less profit/win
  - Few new starts and upgrades = less wins
  - OS reduces barrier-to-entry; harder to assure future business
  - Incentive for unique investment drastically reduced
  - Primes significantly disincentivized for OS Process unless business is at severe risk
- Lower tiers greater than ~ 75% systems cost
  - Face primes' problems + primes vertically integrating and influencing buy decisions
  - Lower tier unstable; caught between economics of DoD, primes, and commercial
  - Much OS use in the lower tiers
- Pressures are driving DoD to become more involved in the lower tiers

Industry will follow if necessary, but not their choice -- Recommend that DoD cause a detailed investigation of lower tier market dynamics and economics

Industrial Base

- Notes (cont.) -

Pilot Program Candidates

There are several programs which would be good candidates to be designated pilot programs for pathfinding implementation of an OS Process:

- National Missile Defense
  - Mission is to achieve and maintain a deployment ready posture until a deployment decision is made, with continuous rolling technology insertion program
  - Largely a System-of-Systems, dependent upon other, evolving systems not subordinate to the program office; dependent upon an architecture-driven modularity approach; long-term viability will be a particular problem
  - Newly appointed Lead System Integrator with good OS perspective and implementation capabilities; good chance of OS Process success
  - Theater Air and Missile Defense
  - Mission is to establish and maintain interoperability between a host of service surveillance, battle management, and weapons programs to achieve an integrated trans-DoD capability
  - Almost entirely a System-of-Systems, dependent upon other, evolving systems non-subordinate to the program office; dependent upon an architecture-driven modularity approach
  - Requirements and CONOPS responsibility rest with JTAMDO and engineering with BMDO. Lead system engineering responsibility for implementation not yet established. Excellent application of OS Process early enough in process
  - Joint Tactical Radio
  - Excellent front-end effort but no real implementation program yet; would be an excellent application of an OS Process early enough in process

Incentives and Disincentives

OS Process Implementation Challenges

Should Be Easy

OS Process is a <u>mindset</u> for architecting

- We already architect Forces, systems, and processes
- We already use configuration control processes
- OS Process is just an additional criteria
- There are industry and DoD role models
- Some programs motivated as survival issue: "cheaper, better, faster" can save programs
- We should be doing it anyhow

Will be Tough

Our processes are dysfunctional obstacles

- Geared for static programs in a static world
  - "Freeze & build"
- Phobic to managing change; ex:
  - Budgeting criteria
  - Acquisition milestones
  - Parts/technology refresh $$

Implementing OS Process is an institutional matter

Incentives

- We have smart people who want to do a good job; we need to ...
  - *Remove the impediments and disincentives*
  - Set objectives and boundaries
  - Include OS achievement as a specific job expectation
  - Evaluate commercial incentive practices
  - Reward OS successes
    - High visibility recognition by Leadership
  - Tolerate thoughtful mistakes
  - *Get out of the way*

Commit to removing the impediments, recognize successes,
Get out of the way

Incentives

- Notes (cont.) -

The Most Crippling Impediments

Most barriers are self-inflicted and entrenched

- Requirements
  - We have stovepiped systems and dead-end technologies because Requirements demand nothing more *[ex: B-2 Defensive Avionics 8088 Processor -- meets requirement]*
  - If we want viable, enduring Plug & Fight/Play systems, then we need to ***require*** them
- System management philosophy -- currently "freeze and build"
  - Baselining to the wrong criteria: frozen detailed configurations vs. F^3I "sockets"
    - Continuous technology refresh throughout entire life of system
    - Leverage supplier evolution and "cheaper, faster, better"
  - Management processes are phobic and dysfunctional in today's world *[ex. management, budget, milestone criteria, test, tools]*
- Legislation and regulation *[ex: Firewalling Dev/IOT&E/Production, Baseline Breach reporting*]
  - Color-of-money inflexibility precludes much technology refresh
  - IOT&E criteria: freezes rather than follows evolving functionality and evolving product configurations

The Most Crippling Impediments (cont.)

- NIH ("Not Invented Here")
  - OS Process is vital for parochial Title 10 interest, but difficult to adapt
  - OSD sponsorship invokes suspicions, vulnerabilities, prerogatives
  - With OS Process, particularly easy to invoke usual excuses:
    - "We're already doing that"
    - "We don't need to do that"
    - "You can't make us do that (Title 10)"
- Lack of intense motivation and vigorous commitment
  - This type of change will not naturally occur -- requires aggressive leadership
    [ex: AF infusion of reliability into TACAIR]
  - Commitment at some lower DoD and industry levels for program survival
    [ex: JSF, IEWCS]
  - Senior Leadership not there yet

OS Process can be done and would have massive benefits, but the barriers preclude its wide implementation

The Most Crippling Impediments

- Notes (cont.) -

Conclusions and Recommendations

Conclusions

- Open Systems Process is fundamental to many DoD priorities that are dependent upon a process-based approach
  - JV 2010 and Service equivalents
  - Force modernization
  - Reduced cycle time and ownership costs
  - Favorable industrial base realignment

Open Systems Process is a Warfighting and Title 10 *essential core value*

- Forces, systems, and processes need to leverage change:
  - Configure Forces, systems and processes for continuous viability
  - Achieve architecture-driven modularity
  - Manage to the natural cycle rates of underlying components
- Open Systems Process is based upon a hierarchy of architectures and standards developed with a performance-based collaborative approach
- Unlikely that DoD can implement Open Systems Process by usual bureaucratic means
  - *Open Systems Process is a cultural and budget challenge*-- process is within our grasp
  - Requires support from DoD, Administration, Hill, and Industry
  - Need to reconfigure Forces, systems, and management processes
  - Removing impediments is most important

Requires aggressive leadership, SecDef and Service Secretary championing

Conclusions

- Notes (cont.) -

Recommendations

(1) Establish Special Assistant for OS Process Implementation

(2) Take Immediate Program Actions

- Direct preliminary efforts
- Designate pilot programs

(3) Institutionalize OS Process

- Implement and mandate Open Architectures
- Revamp management processes

(4) Leadership and Championing

Recommendations

- Establish Special Assistant for OS Process Implementation -

Appoint a Special Assistant for OS Process Implementation within immediate office of the SecDef

- **Focus on *permeating the process*, not individual solutions**
- **Normal DoD mechanisms inadequate to broadly and effectively implement an OS Process** *(ex. existing OSD Executive, Steering Group, Agency, Lead Service, etc.)*
  - Precluded by inexperience and organizational impediments, equities, prerogatives
- **Effective implementation requires empowered advocate, solid OS Process experience**
  - Provocateur, advocate, guide, expert counsel, mentor
  - Map general implementation path, recommend actions and direction
  - Executive advisor to SecDef, CJCS, and staffs
  - Implementation secretariat, staffed by OSD Open Systems Joint Task Force
- **Appointing a Special Assistant to the SecDef is markedly superior to normal mechanisms**
  - Ensures someone with considerable industry and DoD experience
  - Probably no single individual with all the desired experience and stature, but can get close enough to jumpstart the process
  - Have identified a sample candidate from industry (DoD candidates lack sufficient industry experience)
- Could support with a USD(A&T)/VCJCS/ASD(C3I) OS Implementation Board

Recommendations
- Immediate Programs Actions -

There are some specific measures which can and should be taken immediately

- **JCS within nine months amend all MNS and ORDs to require OS Process attributes**
  - Continuing viability
  - Architecture-driven modularity
  - Configure and manage to leverage natural cycle rates of components
- **USD(A&T) within three months direct all programs to**
  - **Develop a Viability Risk Mitigation Program and adapt a preliminary formal OS Process**
  - **Conduct a Viability Risk Analysis and develop a mitigation strategy -- compliance or approved Migration Plan within 1 year**
    - Immediately implement an OS Process to develop architectures, infuse architecture-driven modularity, and capture OS attributes
    - Fully integrate OS Process results into products, management processes, acquisition actions
    - Make OS per OS Process an ***immediate*** mandatory Source Selection Criteria
    - Mandatore milestone review topic at all levels, fully compliant with approved migration plan, within earliest of either two years or two milestone reviews
    - **USD(A&T) immediately designate pathfinding OS Process major programs *(ex: NMD, TAMD, JTRS, etc.)***

Recommendations
- Institutionalize OS Process -

Mandate & fully implement needed DoD-wide interoperability architectures (example domains: C4ISR, weapons systems, M&S, logistics management systems, etc.)

- **For each designated interoperability domain, establish an Architecture Control Board and supporting structure at OSD/JCS and Service levels, and throughout subordinate levels**
- **Suggest an approach based upon classic Program Office Configuration Control Board**
  - Advisory to Line Authorities
    - Establish needed functionality
    - Establish adequacy of proposed architectures and compliance with higher-tier architectures
    - Evaluate proposed changes
    - Assure integrity of processes
    - Establish and oversee compliance mechanisms
  - OSD/JCS Architecture Control Board is additional role of existing ACC
  - Each board should be supported by genuine architects/system engineers acting in the interest of the Line Authority being advised

Recommendations

- Institutionalize OS Process (cont.) -

- **OSD and JCS immediately enforce existing policies or change them**
- **USD(A&T) immediately and explicitly attack each impediment identified by this OSTF and the OS-JTF survey**
- **New Special Assistant for OS Process Implementation within six months roadmap a structured effort to (1) revamp relevant management and oversight processes, (2) establish incentives, and (3) attacking impediments**
  - Example domains for revamping : requirements, cost and budget, program management, support processes, source selection, performance measures, reporting and oversight
  - Coordinate closely with other reform efforts such as Acquisition Reform & RMA
- **USD(A&T) and CJCS direct revamping per the roadmap**
  - Include with other special reform activities
  - Develop end objectives and implementation plans within 4 months of go-ahead
  - First revision of all directed processes within 1 year
- **Immediately grant interim relief for programs to start tailoring legacy program management processes for an OS Process**

Recommendations

- Institutionalize OS Process (cont.) -

- **Establish Task Force to examine implications for industrial base, particularly 2nd and 3rd tier suppliers**
- **Establish structured process for early proactive, consistent, and constructive DoD participation in relevant industry standards bodies**
- **Revise OS-JTF role**
  - Continue current roles
  - Become Secretariat to SecDef Special Assistant for Implementation
  - Nominate more senior director with industry credentials, institutional credibility, and historical perspective on the challenges
  - Augment staff skill mix to include warfighter, program manager, engineer, logistician, cost analysis, budget, and test experience
- **Establish government/industry OS Process Coordination and Advisory Council**

Recommendations
- Leadership and Championing -

- DoD Warfighting and Title 10 capabilities on downward spiral
- ***An Open Systems Process is requisite to many DoD priorities***
- Open Systems Process is no panacea, but is **a cornerstone for all solutions, a historic endowment**
- Implementing OS Process is an institutional issue -- methodology, technology are manageable
- Time is of the essence due to need and change of administration.
- Such change comes only with aggressive leadership *[ex: AF TACAIR]*

Basically a binary choice

- Energetic and dynamic SecDef, JCS, and Service leadership could be decisive
  - ***With it, there is a chance; without it, broad implementation will not happen***
- Would require working with Mr. Cohen and Mr. Hamre to develop a strong personal commitment
- Equal commitment needed from remaining leadership

Task Force recommendations assume aggressive implementation.
If DoD leadership cannot commit, then merely issuing guidance, including OS Process in ongoing reforms, and helping the system do as best it can will not be sufficient

Recommendations
- Leadership and Championing -

- **SecDef within 45 days:**
  - Hold off-site with Chairman, Service Secretaries, Chiefs, CAEs
    - Secure personal commitments to Plug & Fight and OS Process
    - Press Conference
      - Shared commitment and Call for Action
      - Announce action leadership
  - Formally request Dongressional, Administration, and industry support
  - DoD-wide call for identification of impediments to implementation
- **Chairman, Service Secretaries, Chiefs, CAEs, Agency Heads within next 30 days:**
  - Take corresponding actions